Film Bags and Radiation Concerns

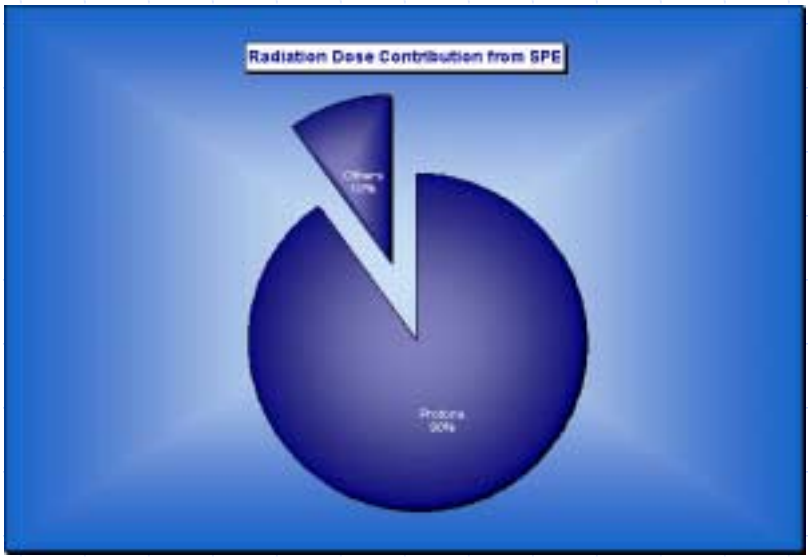
Frank Cucinotta and Prem Saganti

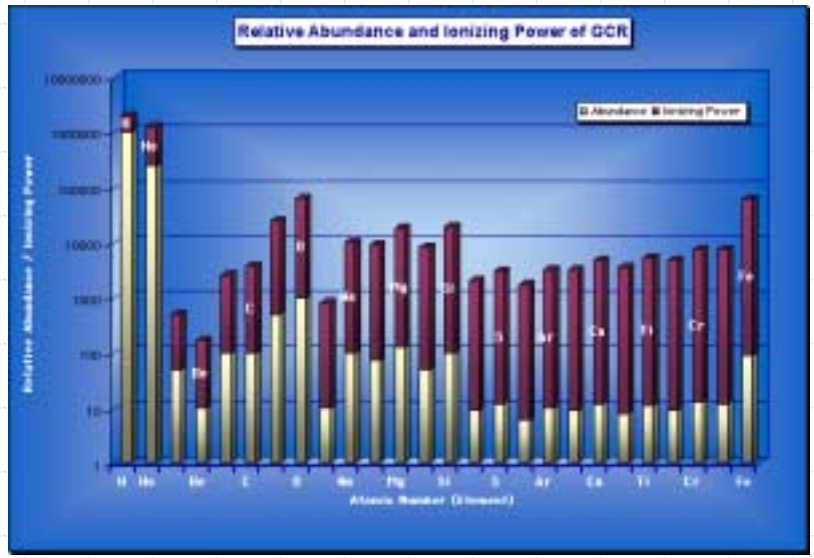
April 3, 2000

Background

- Our experience with film bags:
  - Skylab (high inclination = 50 deg).
    - Two heavily shielded (~ 30 and 50 g cm^{-2}) film vaults on Skylab-2 received higher radiation (0.39 mGy and 0.33 mGy) suggesting that the shielding was “ineffective” in reducing the cosmic rays dose: NCRP-98/1989. Also, large amounts of metal content of the Skylab can be attributed for several secondary effects.
  - HST repair missions (high altitude).
    - STS-82 (HST-2) and STS-103 (HST-3) were subjected to much higher radiation doses than the average. STS-103 film showed significant degradation in the quality.
  - Shuttle-Mir studies (radiation effects).
    - Film on board the Mir determined that “higher the speed higher degradation”. Recommended lower speed film (such as 100 ASA) for minimizing the radiation experiment.

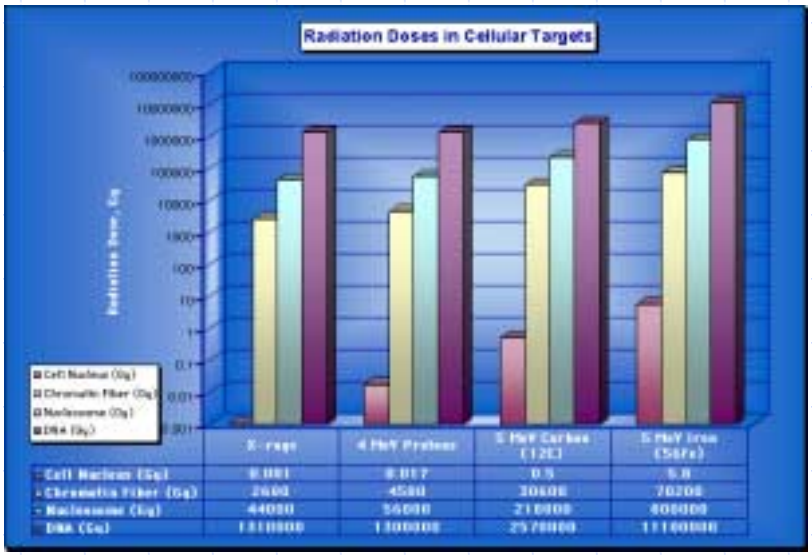
Space Radiation Contribution:
Protons and Other Ions

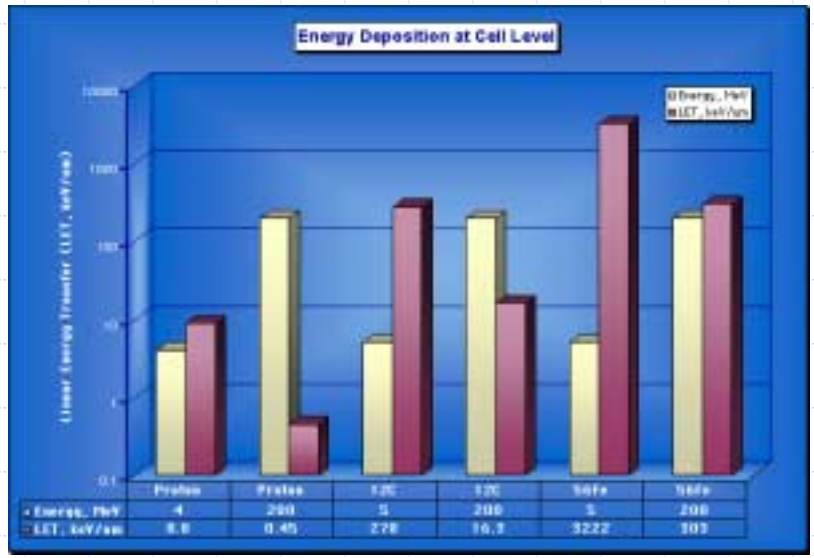




Radiation Induced Damage:

At the Human Cell Level





Major Concerns

- Current Film Bags (containing lead)
  - Film
    - Not enough protection from the space environment
      - Radiation damage of the film could result in loss of contrast, sharpness, and color degradation
      - Secondary radiation from lead (like the neutrons) can increase the film damage significantly.
  - Crew
    - Can produce secondary effects of radiation
      - Close contact and proximity of these bags imparts the concerns with the low energy secondary radiation produced
      - High atomic number of lead (z=82) can be of greater concern for secondary radiation (neutrons and etc.)
      - Short term concerns of secondary effects (2 weeks-Shuttle)
      - Long term concerns of secondary effects (2 months-ISS)

Approach

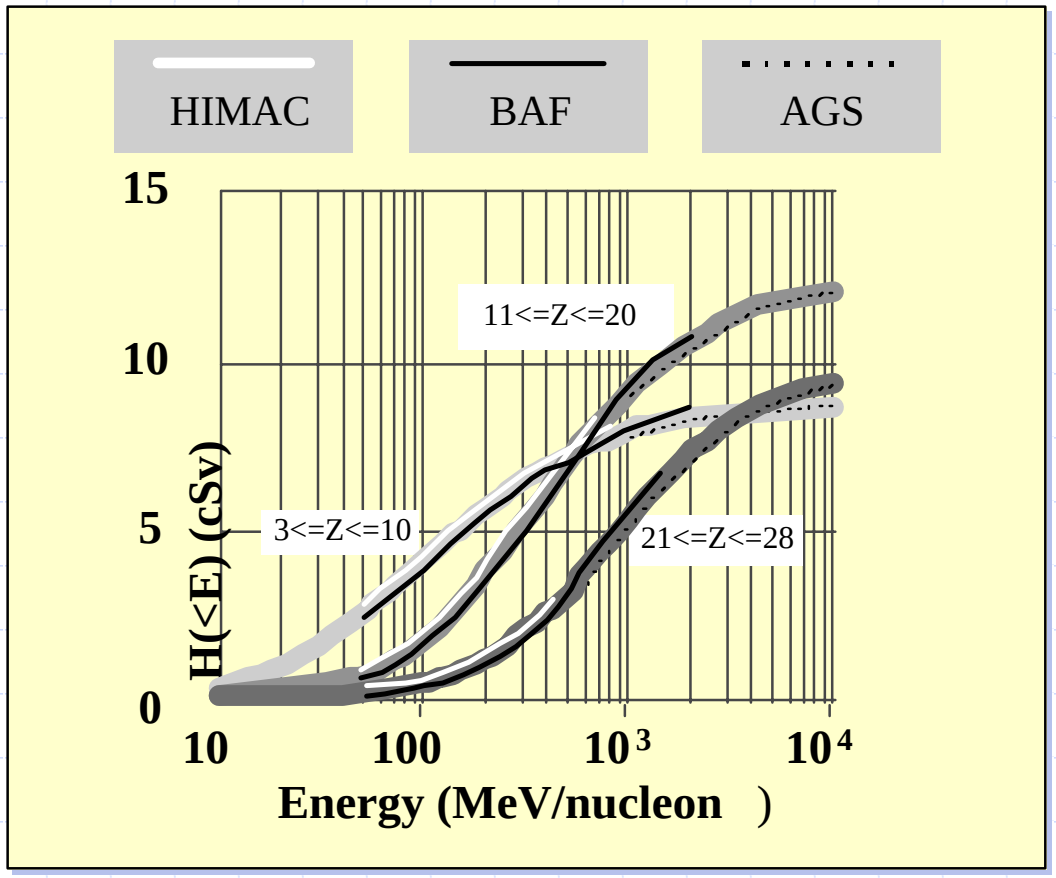
- Step-1:
  - To identify the material(s) for film bags that can provide adequate protection for film and eliminate the concerns due to lead content
- Step-2:
  - To recommend the prototype(s) concept of the film bag to the RHO and to the Program
- Step-3:
  - To evaluate the current bag vs. the new concept bag(s) simultaneously (ground based accelerator studies)
- Step-4:
  - To evaluate the current bag vs. the new concept bag (both short term and long term on-board studies)

Accelerator Opportunities

- Ground based studies
  - To simulate and evaluate space environment effects
    - LLU (April-2000)
      - Proton beams (up to 250 MeV about 50 cm dia)
    - HIMAC (April-2000)
      - He, C, Ne, Si, Ar (up to 1GeV about 22 cm dia)
    - BNL (October-2000)
      - Fe, Si (up to 1 GeV about 20 cm)

Particle Energy Range Available for Research

BNL: AGS (current) and BAF (2003), (HIMAC in Japan)

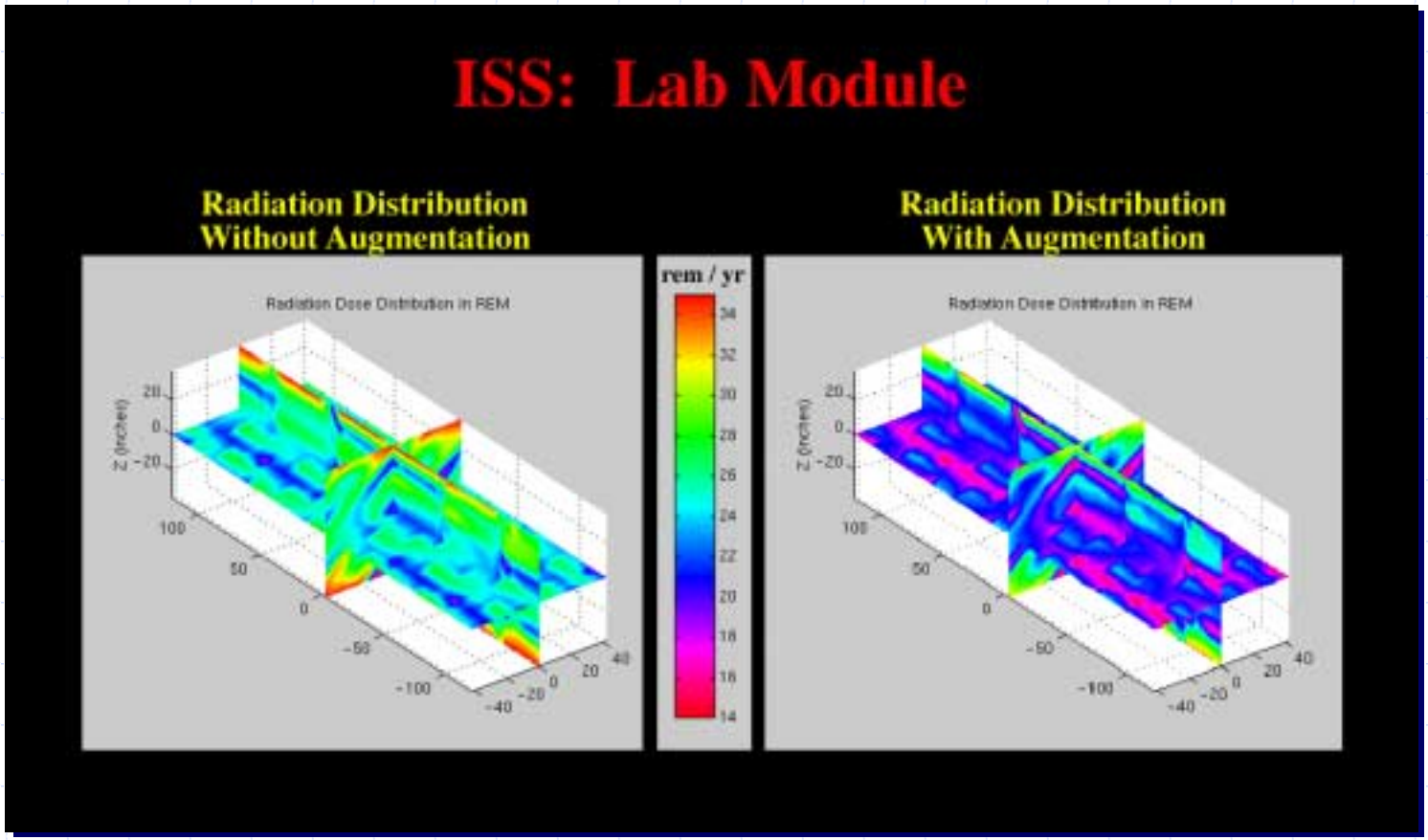


Credit: W Schimmerling / NASA

Plan-A

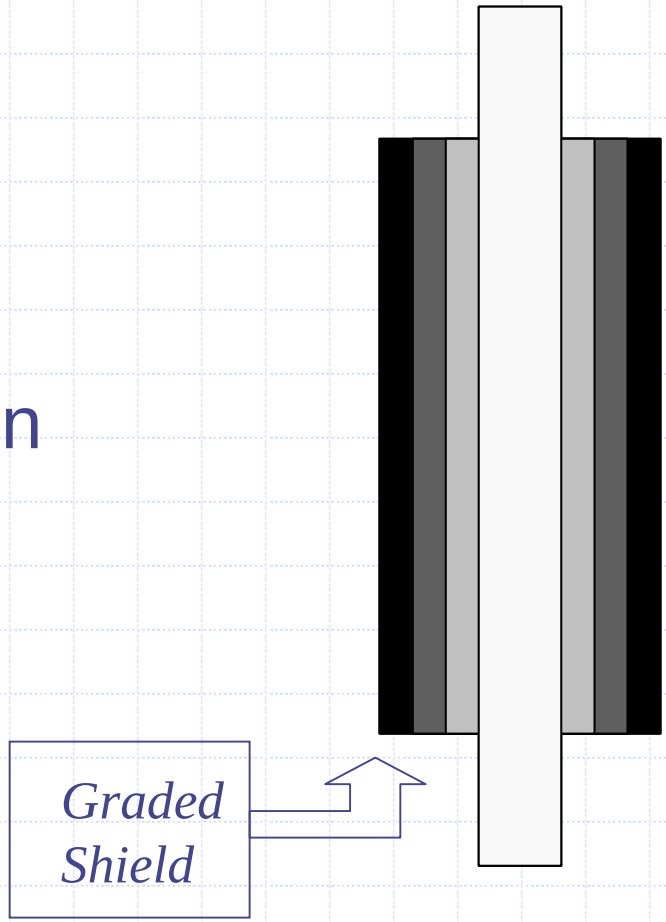
- To evaluate a single promising material and address related constraints (such as volume limits)
  - Ex. Polyethylene (CH_2, density 0.92 gm/cc)
- To evaluate multi-layer graded shielding approach
  - Polyethylene (CH_2, 0.92 gm/cc)
  - Polyetherimide ($C_{37}H_{42}N_4O_6S$, 1.27 gm/cc)
  - Polyimide ($C_{22}H_{10}N_2O_5$, 1.42 gm/cc)
  - Others (?)

Advantage With Additional Shielding:
Polyethylene



Plan-b

- To augment the current film bags with a new graded shield concept for improved protection (both for film and the crew)



Testing With Film

- Expected type
  - Color positive (100, 200, and 400 ASA)
  - Color negative (400 ASA) for immediate damage recognition
  - Others (?)
- Expected exposures
  - Air force resolution chart
  - McBeth color charts
  - Others (?)

Testing With Film

- One control set and several exposed sets for irradiation testing
- Measurement of radiation at the film
  - TLD (Thermoluminesence detectors as used on STS) that can be placed on the film cans for measuring the radiation dose received

Conclusions

- A new prototype bag to be developed soon
- Suggested bag concept needs to be tested for appropriate recommendation
- Suggested prototype bag needs to be evaluated with film for its worthiness
- Testing opportunities are immediately available (in April-00) for evaluation and can be achieved

For More Info of the Space Radiation Health Project

http://sn-saganti.jsc.nasa.gov/SRHP/